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FARADAY.

DR. GLADSTONE'S lectures at the Royal Institution have forcibly brought into prominence that "great and good man," Faraday. Lecturing from the same table that he lectured from, using the same apparatus that he used, illustrating the very discoveries that he made in that very place, it was impossible for the lecturer to avoid frequent reference to that illustrious philosopher. Every mention of his name was greeted with a round of applause from the demonstrative juveniles present, showing that the knowledge of the good he had done was well known to those who never could have heard him, while from those that had heard him, and had listened to his clear and lucid descriptions, a grateful cheer testified to their appreciation of the just tributes paid by the lecturer to his memory.

Faraday's whole character is a pattern to all young aspirants to scientific fame. The son of a poor blacksmith, the apprentice to a bookbinder, rose, by steady perseverance, determined application, and sterling worth, to be one of England's greatest scientific worthies. His motto was "experiment." He interrogated Nature in every conceivable form. Experiment was to him the great test of truth. and he accepted no fact until it was confirmed by observation and experience. Thus, in the severe cross-examination he gave Nature, he discovered those various forms of electricity and properties of matter which have made his name immortal. Foreigners, more demonstrative than his own countrymen, have named his great discovery—magneto-electricity—*Faradaism;* and in medical phraseology the term *faradisation* is creeping into use in contradistinction to galvanisation—the one being the effect produced by the intermittent currents of magneto-electric induction, and the other the constant influence of voltaic currents. His views on the nature of electricity, and the way in which electrical action is propagated by molecular action, have not yet received general acceptance abroad, though indications exist that his ideas are gradually percolating the scientific schools of the Continent.

His researches are a model of method, system, and order. They are out of print, and very scarce. No electric library should be without them. No student should be satisfied until he has read them. It is strange that some enterprising publisher does not republish them. They are full of the simplest and most beautiful experiments; and though the flights of his genius have frequently taken him to prophetic and seer-like views, beyond the comprehension of the tyro, the descriptions and explanations are generally so clear and exhaustive that they carry conviction with them.

Tyndall wrote of him:—"The fairest traits of a character sketched by St. Paul found in him perfect illustration; for he was 'blameless, vigilant, sober, of good behaviour, apt to teach, not given to filthy lucre.' He had not a trace of worldly ambition; he declared his duty to his sovereign by going to the levée once a year, but beyond this he never sought contact with the great. The life of his spirit and of his intellect was so full, that the things which men most strive after were absolutely indifferent to him. 'Give me health and a day,' says the brave Emerson, 'and I will make the pomp of emperors ridiculous.' In an eminent degree Faraday could say the same. What to him was the splendour of a palace compared with a thunderstorm on Brighton Downs? What amongst all the appliance of royalty to compare with the setting sun? I refer to a thunderstorm and a sunset because these things excited a kind of ecstacy in his mind, and to a mind open to such ecstacy the pomps and pleasures of the world are usually of small account. Nature, not education, rendered Faraday strong and refined. A favourite experiment of his own was representative of himself. He loved to show that water in crystallising excluded all foreign ingredients, however intimately they might be mixed with it. Out of acids, alkalies, or saline solutions, the crystal came sweet and pure. By some such natural process in the formation of this man beauty and nobleness coalesced to the exclusion of everything vulgar and low. He did not learn his gentleness in the world, for he withdrew himself from its culture; and still this land of England contained no truer gentleman than he. Not half his greatness was incorporate in his science, for science could not reveal the bravery and delicacy of his heart.

"But it is time that I should end these weak words, and lay my poor garland on the grave of this

'Just and faithful knight of God.'"

THE number of messages passing over the Cuba Submarine Telegraph Company's line during the month of December, 1874, was 2073, estimated to produce about £2300, as against 726 messages, producing £742 in December, 1873.

THE traffic receipts of the Western and Brazilian Telegraph Company (Limited) from the 20th November to the 25th December (five weeks) were £12,764 17s. 4d.

THE receipts of the Submarine Telegraph Company for the month of December, 1874, were £7895 10s. 4d. those for the corresponding month of the preceding year amounted to £7933 19s. 8d.

THE VOLTAIC BATTERY.

A Course of Six Lectures,

By Dr. JOHN HALL GLADSTONE, F.R.S.,
Fullerian Professor of Chemistry, Royal Institution.

Delivered at the Royal Institution of Great Britain.—Christmas, 1874-5.

Lecture I.—The Cell and its Effects.

Ladies and Gentlemen,—I am glad to see that this room is so well filled; but while I thoroughly welcome all of you elders, who have done me the honour of coming to hear the lectures, it will be understood that I address my lectures especially to the juveniles who occupy the front rows of seats, and I shall endeavour to confine my thoughts as much as possible to them.

And now, girls and boys, I want to bring before you this subject of the voltaic battery in such a way that you can understand it, and can repeat the experiments, as far as they lie within your power. I shall endeavour to perform various experiments with such simple means as you may find in your own homes, or which you may buy at a small expense, so that when you go home you may repeat them for yourselves. You will, in that way, learn a very great deal more than from any amount of listening to me, and you will thus get experience for yourselves, and grow up young philosophers.

I want, first of all, then, to show you how we can produce the thing which we call the voltaic force, or galvanism, or dynamical electricity. I shall produce it by means of three very common things —copper, zinc, and sulphuric acid.

With copper you are all familiar. Here are specimens of copper of different sorts. You know it as this red metal, which is capable of being drawn out into wire, capable of being hammered into various forms, and worked up into different articles. Here is some Japanese copper, of a somewhat different colour. I need not enter upon a fuller description, because you know the metal very well.

As for zinc, you may not be so familiar with it; but here are different forms of the metal. You will observe it is a greyish-white metal, not so white as silver, but whiter than lead. Here is some in the form of sheet zinc. This, again, has been dropped into water, so that we have it granulated; or we may have it in the form of beautiful crystals. It cannot be drawn out into wire or hammered out like copper, for it is a much more brittle metal. When this crystalline form is struck, you see how it breaks from one side of the block to the other. Probably you are most familiar with zinc through its being used for chimney-pots which are put up for curing smoky chimneys, and for purposes of that sort.

Well, then, we take these two things,—copper and zinc,—and we take a fluid with them. We cannot get on at all without a fluid body, and one that consists of two parts. I take sulphuric acid; here is some in this bottle. It is a heavy liquid, having nearly twice the weight of water. It is a thick liquid, for, if I shake it, you see that it looks oily, and the bubbles take a long time in rising. This is very different from water. In fact, there is no water, or very little water, in the bottle. This liquid is very corrosive. You can get it at the chemist's, and it is one of the cheapest things that are sold; but you must be careful how you use it. You see how it corrodes things. I will pour some of it on this piece of wood, and we shall soon see that the wood will be stained. Then suppose I take a little sugar, instead of wood: here is some sugar which has been already dissolved in water, to save time. We pour the sulphuric acid into the solution of sugar, and we shall find that we get an effect. [The solution became black and greatly swollen upon the addition of the sulphuric acid.] You see how violently the sulphuric acid acts upon the sugar. Here is a cloth: you will see the corrosion on the cloth when I pour sulphuric acid upon it. It does not become precisely black, but you see what a destructive effect the acid has. That is the sort of effect often produced upon the cloths which we use in our laboratories, and I wanted to show you the experiment in order that you may be careful not to get the sulphuric acid upon your clothes, or upon table-cloths or furniture. I have no doubt that those friends who occupy the upper benches of this place will be better pleased by your experiments if you reduce as few towels to this condition as is convenient. If I were to mix the sulphuric acid with water it would produce a considerable amount of heat. I will show you that. I will take about equal parts of water and sulphuric acid. I am the more desirous of showing you this effect, because it will be necessary that you should add water to the sulphuric acid when you experiment with it yourselves. I have poured the two liquids together, and the glass has become very warm. You see, when I wet it, how it steams. In fact, it is so hot that I cannot bear my hand upon it for any length of time. I suppose that the heat of the mixture is now about that of boiling water.

Suppose we take some of this metallic zinc and sulphuric acid, and put them together; what do we find? Here is the metallic zinc; I will add to it the sulphuric acid, and you will soon see that something takes place between the two. There is a movement, and there are bubbles formed which will speedily rise; they consist of hydrogen gas. This gas is lighter than the atmosphere, and therefore ascends very rapidly, and, in fact, it will take up with it any light object. There is some being produced in this vessel, and we will inflate this balloon with it. As the operation will take some little time, I will begin to inflate the balloon now. This gas will take fire very easily, and will burn with a slightly luminous flame. I do not want to set fire to it too soon after it begins to bubble up; and I will warn any of you, who make this experiment, against applying the light before all the air is driven out. The reason is that, in such a case, the apparatus will blow up. That is what constantly happens with young experimenters when they are dealing with hydrogen. You see I can now ignite it, and there is the gas burning away. Now, instead of burning it in that manner, I will collect some of it in this vessel, and we shall soon have a large quantity of it. In the meantime our balloon will be filling. I might show you that hydrogen is a light gas by turning it from one vessel to another, if I pleased; and you would see that I should have to pour upwards, instead of pouring downward as you pour most things; but time presses, and I will not show you that. [A jar full of hydrogen was

collected over water, and then removed from the trough.] You see I can lift up the gas in this way, and carry it about where I please. I will set fire to it, and now, you see, I can pour the gas out by turning the mouth of the jar upwards, and pour the flame up into the air as the gas ascends.

The balloon which I showed you just now is already filled with gas. The hydrogen is capable of carrying the balloon up into the air, and no wonder, as it is nearly fifteen times lighter than air. I mean to keep the balloon captive, for if I were to let it go it would probably find its way into those lamps, and then we should have a combustion on a very large scale. The hydrogen is capable of carrying not only the balloon itself, but the piece of india-rubber tube that is attached to it, and by which the hydrogen was put into the balloon.

We find, therefore, that if we take zinc and put it into sulphuric acid an effervescence takes place; there are a great number of bubbles produced, and these bubbles are not bubbles of air, but of this very light gas, hydrogen, to which we can set fire. But now I want to show you that not only has gas been produced, but something else has been formed at the same time.

I omitted to speak of one property which zinc has, and in which it differs from copper. It is difficult to set copper on fire. I do not say that we chemists cannot do it, for we can do a great many strange things; but we can very easily set zinc on fire. I do not say that it will burn as easily as paper or wood: but if I throw little pieces of zinc into the fire you will see that they will burn. Mark that beautiful flame which is rising in the fire; that is caused by the burning of the zinc. Here are some zinc shavings mixed with wooden shavings, to make them catch more easily. We will set light to the wood shavings, and then blow upon the mixture; we shall thus make the zinc burn. I draw your attention to these white clouds of smoke rising from the burning zinc. You see the beautiful colour of the flame. These white masses of smoke which are rising in the air consist of a combination of zinc with the oxygen of the air. The compound thus formed is oxide of zinc. It is falling down as a kind of permanent snow,—not like the snow that is outside this building, but a snow which will not dissolve. I dare say that it is falling down upon you in various parts of the room. You will bear in mind, then, that this is white oxide of zinc.

Now I will take the vessel in which the zinc has been dissolving in sulphuric acid. The vessel has become so hot that I must take it up with a cloth. I will pour a little of the liquid out, and what I shall find is that some zinc has dissolved in the acid. I will not show it to you as zinc, but as that white oxide—the same sort of thing as was floating about in the air just now, after the zinc shavings were burnt upon the table. Here I pour in some potash in order to take away the acid, and you perceive some white stuff floating about in the liquid; that is oxide of zinc. The liquid has now become quite thick, with this white oxide suspended in it. If I had taken some of this liquid and poured it off into a basin, and put it over a lamp and evaporated off the water, we should have obtained a crystallised salt called sulphate of zinc. When you look at it from a distance it is something like common salt, but when you come to look at it more closely you will see that it is quite different in its crystalline appearance, like the fine specimen on the table.

We thus have seen what takes place if sulphuric acid and zinc are put together. Now suppose that instead of taking sulphuric acid and zinc, I take sulphuric acid and copper. Here is a sheet of copper; I put it into the acid, and what happens? I do not know whether any of you can see anything happening; I cannot. The fact is that if the two things are perfectly clean nothing at all happens. The copper and the sulphuric acid have nothing to say to one another whatsoever. You know very well, from what I have shown you, that if I had put a plate of zinc into the sulphuric acid we should have seen an action at once set up, and there would have been little bubbles of hydrogen gas floating from the zinc. I will now put the plate of zinc into the acid with the copper, and I thus get together the three things which I want. I get the copper, the sulphuric acid, and the zinc in the same vessel; but at present, as they stand, the zinc is dissolving away through the action of the acid, and the copper is doing nothing at all. But if I cause them to touch, either under the water or above the water, or in any sort of way, then we see that bubbles begin to come upon the copper as well as upon the zinc. I have now made them touch under the water, and I see the bubbles coming upon the copper in great quantities. Supposing that I did it in another way, and that, instead of causing the two metals to touch together under the water, I were to make them touch by means of a wire, or any other piece of metal, above the water. Here is a pencil-case; and if I cause it to touch the two metals, I still find that the bubbles will come upon the copper just as much as when the copper and the zinc were touching together below the surface of the water. But the copper is not dissolved at all. It is the zinc that is dissolving, although the bubbles come upon the copper. This appears still more if I take some zinc which has had mercury rubbed over it. You can easily cover the zinc with mercury. Take a little mercury, and rub it over the zinc, and that will cause the zinc to last much longer, and to be much more satisfactory. If we put this zinc which has been covered with mercury into sulphuric acid, it does not dissolve; but if I touch it with copper we shall find streams of bubbles coming from the copper.

Here, by means of this arrangement, we get a cell for the first time. This is a simple cell, made of the most simple materials that I can bring together, and which cost next to nothing; and you can repeat the experiment very easily. You must add to the sulphuric acid a good deal of water,—perhaps six or eight times its own bulk. You can make use of any glass, such as a tumbler, for the purpose of the experiment. Look at it carefully, as it is passed round the room. Of course you must take care, as I have told you, not to get the sulphuric acid upon your clothes, or upon your gloves. I want to show you this cell on a larger scale, so that you may all have the advantage of seeing it together. Here I have a large vessel containing dilute sulphuric acid. I will first place in it a piece of common zinc, and, instead of your seeing it by means of the ordinary daylight, we will throw on it a beam from the electric lamp, and then you will see the effect very clearly. We must

have darkness in the room, in order that you may see the experiment properly. You will now see, on a large scale, just what you saw in the little tumbler which I used at first. I want to make a battery of this large vessel. We have now got a good stream of light upon it, and I will put the plate of zinc into the sulphuric acid. You will see that there are bubbles of gas coming upon the surface of the metal. Presently they will become more evident. There they are. Now they are getting scattered throughout the water at a distance from the zinc. Suppose I were to take this plate of copper, and place it in the vessel. The light is now shining upon the copper, and you can see that there are no bubbles upon that metal, or, at least, there are none worth speaking of,—certainly no stream of bubbles. I will now bring the two plates into contact, and you see that the copper at once becomes white, in consequence of the great number of bubbles that flash from it. There you see a stream of bubbles pouring up from the copper, especially from that end of it which is nearest to the zinc. I will now take the copper away from the zinc, and you will soon see that the bubbles all disappear, and will not come again. I will now remove this zinc plate, and put into the cell a plate which has been amalgamated,—that is, has had mercury rubbed upon it. You will now see that, in the first instance, no bubbles will come upon the amalgamated plate. There it is, in the strong beam of the electric light; but, close as I am to it, I see no bubbles, excepting a few that have been floating about the liquid. Just a few bubbles have now formed upon one edge of the plate. I do not know why that has happened, but probably the plate had not got properly amalgamated there. If I touch the zinc and the copper plate together, bubbles will come upon the copper at once. I have now made the two plates touch together near the bottom, and you see how bubbles at once come upon the copper. Suppose I touch them above the liquid instead of under the liquid, still the bubbles come on the copper at once, though the copper is a long way from the zinc. Suppose that, instead of actually touching the plates themselves, I join them by metal in some other way. I will presently join them by means of a wire; but, first of all, let me take any straight piece of metal, without any mystery about it, and join the plates together by means of it. Bubbles at once flash upon the copper directly the piece of metal touches both plates. The same thing happens if I join the two plates by means of a wire. I will now join the plates,—I was going to say in a more scientific way, but that would be wrong, for the simpler a method is the more scientific it is. I will now, for convenience sake, put upon the plates of metal binding-screws, by means of which we can hold anything to the plates very easily, and which we shall find very useful as we go on. I put a binding-screw on each plate, and attach wires to them. At present these two wires are not joined, and there are no bubbles, but directly I join the wires white bubbles of hydrogen appear, and whiten the copper plate as before. There they are. I now cease to join the wires, and the bubbles will go off. I now want to show you a few things that happen when these wires are brought together. I do not know whether you can see little sparks at the ends of the wires when they are brought together; but I can see them. It requires to be rather near in order to see the sparks, but I dare say there are a great number of bright eyes in the room that can see them. If any little boys or girls would like to come and see the sparks, they can be the spokesmen to the others of what they have seen. You may notice that the sparks occur when one wire is caused to touch the other, and is then separated from it.

We will now let that cell go working on, and we will make it do something else. I have here a magnet, and I can cause these wires to alter its position. The magnet is lying along under this wire. It is very easy to make this instrument. You can take any little magnet that is easily suspended, as this is, on a needle driven through a board, and stretch over it a piece of wire lengthwise. There is a piece of blue paper on one end and a piece of red paper on the other, so as to show the two opposite ends of the magnet. It is lying quite steady at present in the meridian of north and south. I am going to make the wire of the cell part of the wire attached to the magnet. Directly I bring the two wires together, away goes the magnet, and it does not swing back again in a hurry. It has been set swinging by the current that has gone through the wire, and it comes to rest in a different position. If I break the wire, the magnet goes swinging back again to its first position. I will now let it come to rest a bit, and we will see what more I can do with it. You recollect that I made the blue end swing in a particular direction. I will now take the wires of the cell and join them to the opposite ends of the wire over the magnet, and you will see that the blue end will swing round to the other side. Thus you see that one effect that we can get is to turn a magnet out of its position, and we have done that by means of our single cell.

We will now take a piece of iron, which is not a magnet, though it looks like one. It is a piece of iron in the form of a horseshoe, and with wires twisted round it, such as you can buy in any philosophical instrument maker's shop very readily. I said that it was not a magnet. You see that it does not attract iron. It will not hold this "keeper" at all. But now I will make the wire which is twisted round it join with the wires from the cell, and we shall see what happens. We now find that the piece of iron has become a magnet. It will now hold this weight very well, and I hardly know how to get it off again. I dare say it will hold other weights besides. Here is a seven-pound weight. Let us see whether it will hold it up. It will scarcely hold so large a weight as this; but it will hold up this one (a four-pound weight). You see I have turned this piece of iron into a pretty powerful magnet, by just joining the wire which is round it with the wires from the cell.

There are other effects which this cell will produce. I may handle these two wires with perfect impunity. You see I take these wires in my hands, and I am not at all afraid of getting any shock upon my body in that way. But still I could produce certain effects upon the body with these wires. For instance, if I were to put them around my tongue, which is more sensitive, I should get a very peculiar taste. I do not say whether it is an agreeable or a disagreeable taste. I have had a number of pieces of zinc prepared here, so that you may have some of them, and try the experiment

with them afterwards. You take one of the little pieces of zinc and a silver coin, put them on each side of your tongue, and allow them to touch, and you will get the same effect as with these wires. You may try that experiment afterwards at your own pleasure if you like to take away some of the pieces of zinc.

Now I want to take these wires, and do another thing. I will make them broad at the ends, and for this purpose I will take another metal—platinum. It is necessary that I should employ platinum in this case, though it does not give any new galvanic effect; and you may consider, therefore, that I have made the copper wires broad at the ends by joining these pieces of platinum. We have poured upon this paper a solution of iodide of potassium and a little starch. Now iodine has the peculiar property of turning starch blue; and if we can set free the iodine from the iodide of potassium we may expect to see the blue colour. Let us see whether that cell is able to separate the iodine from the potassium. I place the two wires one upon another; but there is paper between the two, and there is no contact—at least, there is only contact through the liquid itself. Now let me separate the two from one another, and see what we have. There is the mark of this platinum plate in blue upon the paper. We have, therefore, effected a chemical splitting up, or chemical decomposition.

Here, then, we have various effects produced from our one cell. I have taken merely one plate of zinc and one plate of copper, and dipped them into weak sulphuric acid, and you see what we have obtained. We have got this strange transference of the hydrogen from one plate to the other. It is the zinc plate which dissolves up; but the hydrogen appears upon the copper plate. But we have effected more than that. We have produced the little sparks which some of you saw; we have caused the turning or "deflection" of the magnet; we have made a piece of soft iron into a magnet, and we have decomposed some iodide of potassium, so as to split it up into potassium and iodine. There are one or two other things that we could have produced if we had had a more powerful cell than that. I will now take a more powerful cell, or, rather, I will take a number of cells. I am not going to show the cells here, and I am not going to use a great number of things as big as the cell which I have been using; but I shall make use of a great number of cells of a more powerful kind, and which form what we call a battery. Here is one lot of them containing five cells; and we have two or three little arrangements of that kind about the house, with wires coming up from them; and by this means I can turn on a great deal more power than I had before. Instead of employing one large cell, as I have been doing, we can take several cells, and cells of greater power.

Now let us see what effects we get with these powerful cells. First of all I should like to show you something which I did not show you before. We will take a long piece of platinum wire. Here are two ends of wire which I can tie together; and here are some iron filings. I can get this wire covered with iron filings, which will stick to it, and I can thus turn these filings into little magnets. Now I break contact, and the filings drop off, just as the weights dropped off the magnet. I will now take these long wires and twist them round these stands, so as to make these stands part of my wire. You must know that when I am talking of a "wire" I do not mean merely what you commonly call a wire; but if I put on any piece of metal between the wires I call that piece of metal a wire. It is, in my eyes, part of the wire which runs from one plate to the other. I now join this platinum wire on between the two wires, and there you see the current going through. The current has made the platinum wire red hot, and although there is the usual light in the room, you can see how bright the platinum has become. We will make the platinum wire a good bit shorter, and I daresay that we shall find it still brighter than it was before. It has now reached a white heat. Let us have it shorter than that. There, the current has now actually melted the platinum wire, although platinum is one of the hardest of all the metals to melt. Now, instead of taking a platinum wire, I will take an iron wire. The iron becomes red hot; now it is broken, and the iron is actually burning and blazing away on the table. You thus see what a heat we can produce by means of this battery by passing the current through thin wires.

But, beside this intense heat, I want to show you other effects which we can produce. I should like to show you some more of those magnetic effects. Here is a little magnet which is capable of being moved, and we can send a current through it by taking part of it into the wire of our battery, and when we do that we shall find that the magnet itself will move. You see, away it goes spinning round and round. We are actually making the magnet rotate through sending a current through part of it in this way. If we were to reverse the position of the wires, we should send it round the other way. We will try. There it goes spinning round in the opposite direction. Here I have a pleasant piece of apparatus by which a shock can be given. I am not going to give you all a shock at this present time; but if any of you like to try it afterwards I can pass the current through a great number of you all at once, and you can all have the pleasure of a shock at the same time; or if any girl or boy is greedy enough to want the whole force of it to himself, he may have as much as ever he likes from this apparatus.

During this course of lectures I shall have to introduce to you several pieces of apparatus worthy of all honour, and this large magnet is one of them. I do not mean that this is particularly valuable because it is very large, but because there are associations connected with it. It is not difficult to get a great magnet like this; you can buy one. But this particular magnet, which belongs to the Royal Institution, is one that has a history and a character. It was made long, long ago, by that great and good man—Professor Faraday; and so you are looking at his great electro-magnet—that with which he did a great deal of his very best work. He used to look at that magnet, and work with it, and imagine the forces which were revolving about it. To a certain extent it is clumsily made compared with the magnets made now-a-days. It is, I believe, formed from one link of an enormous cable cut across, and these wires have been twisted round about it. It is, on a large scale, just like this little magnet of soft iron. We can pass a current from the battery round about this large magnet, and produce much greater effects than we did before.

Instead of being able to hang only a seven-pound weight upon it, I could hang almost any weight I pleased upon the large magnet. I could hang myself upon it quite easily. I will, first of all, take some of these little filings, such as I had just now, and spread them on this sheet of paper by means of a pepper-box. I will scatter them over the surface of the paper which rests on the ends of the magnet. If the power is sent through the magnet we shall see certain effects. I shake the paper, and you perceive how the filings burst into broad lines, and form themselves into ridges, and wander about in various directions. We see that they are arranging themselves, not only on the poles, but are standing up and bending over in various directions. If I turn the magnet down, you see that they do not fall off, although the paper is pretty nearly vertical. They are standing up like a brush. Suppose that, instead of taking little things like filings, I take some of these nails; you will see that they do the same thing. I can pile them up in this way, and make a bridge of them. It is very hard indeed to pull them away. When I look at these things I think of Faraday, of whom I was speaking just now, and I think of his enthusiasm, and how he used to attract little boys and girls, and infuse his own enthusiasm into them, and make them magnets too. These nails become magnets, but after breaking the connection they cease to be so, and fall off; but I hope that in the case of a good man like Faraday the influence remains after he is removed, and that many who have been attracted by him do continue to attract others in their own little way. If these nails were made of steel they would remain magnets, and would retain a good deal of their magnetism when the contact was broken. Even so I hope many of you may be permanent magnets.

I will now take a common poker and turn it into a magnet. If you have a voltaic battery you can do that for yourselves. We are going to try it with a strong battery, and you will see that the poker round which this protected wire is coiled is turned into a magnet; and I dare say that we shall be able to pick up any of these nails with it. You see that the poker, when thus made into a magnet, is able to take up the nails, and each nail is turned into a magnet itself, and attracts others, so that the power is communicated from one to the other; but if the contact is broken, off these nails fall again.

I just now spoke of the spark. I shall not show you the electric light just now, for I must reserve all I have to say about that until another time, when I hope to do justice to it. Neither will I show you any more decompositions to-day, for I am going to devote a whole hour to the subject of experiments of that kind; but I wish to show you the spark going through rarefied gases. The spark, as we have already seen it, goes through the common air; but if it is made to go through rarefied gases it will have a different appearance. While that is being prepared here are two pieces of coke just taken up from the grate, and we will make the spark pass through the air between them. You see the intensely brilliant light which is produced in this way. It is a light rivalling the sun itself.

Mr. Ladd has now arranged an experiment by which we shall see the spark as it goes through rarefied gases;—In the glass tubes before you there are certain gases and certain liquids which have a peculiar optical property, and which take up the electric light and send it forth again. We will now cause the current to pass. [Various brilliant effects were produced by means of vacuum tubes.] This light is not only a beautiful lambent, coloured light, flowing in masses and clouds through these tubes, but it is broken up into various bands and striæ, and it pours from one vessel to the other; but you must see it near at hand in order to estimate its full beauty.

We have now obtained from the single cell with which we started various extraordinary effects. We find substances appearing where we should not expect them to appear; we find that we can produce heat, or sparks, or shocks to our nerves; that we can make magnets, and twist magnets round; and that we can produce a thousand chemical decompositions, if we like, by means of this force. What a wonderful force this is! I dare say many of you boys are well acquainted with the old classic myth of Proteus, and you know that Proteus was said to have many secrets; but if any mortal caught hold of him he would try to elude his grasp, and escape from him as a flash of lightning, or as a tiger, or as running water, or as wind. Now this voltaic power is something like Proteus. We find it changing into these various forms. Sometimes it appears as chemical action, sometimes as heat, sometimes as light, sometimes as a feeling in our nerves, sometimes as magnetism; and what we have to do is to try and get hold of him as Proteus was secured. They had to catch Proteus in his den, when he was asleep, and put a chain around him, and then they could make him tell his secrets. And so we, in our next lectures, will endeavour to trace this force to his den, and so enchain him as to make him reveal his origin and all his mysteries.

FIFTY YEARS' PROGRESS.

Few things in our day have experienced such rapid development as the electric telegraph. It is true that nearly 2000 years ago the keen-sighted, inquisitive Greeks had set about to inquire into the source of that marvellous power which we call electricity, and it is equally true that this invisible force must have existed a long time prior to the inquiries of these ancient Greeks. But the practical application of it, as it exists in our day, is a thing of comparatively recent origin—so recent, indeed, that many of the early disciples of electric telegraphy have lived to witness the realisation of all their hopes, and more. As early as the year 1600 the subject of electricity and magnetism began to engage the attention of thinking men in England and throughout Europe; and to this period belongs the Latin treatise of Dr. Gilbert, of Colchester, which may be said to have been the first really practical work on the subject. Then followed the discoveries of Stephen Gray, a pensioner of the Charterhouse, Du Faye, Franklin, Galvani, Volta, Sir Humphry Davy, Ritter of Munich, Oersted, the celebrated Danish philosopher, Arago, Sturgeon, and Faraday. These, however, had all laboured more or less in the higher field of electrical science; although, as a matter of course, their labours tended in no small degree to bring about the consummation which very speedily followed the important discoveries of Faraday about the year 1830. Prior to this—viz., in 1753—one Charles Morrison, described in the *Scots' Magazine*, under the initials "C. M.," his so-called "Expeditious Method of Conveying Intelligence;" but although his

system may be said to have contained the germ of that now in use, it was so costly, and so little "expeditious," that it required a separate wire for each letter of the alphabet, and practically a separate apparatus for each wire. Morrison's plan was reproduced some twenty years later—in 1774—by one Le Sage, a Frenchman, who submitted it to Frederick of Prussia as an original method of electric telegraphy. But it soon dropped out of notice, both in this country and abroad; and, as is well known, the first really practical telegraphs belong to the year 1837, when Messrs. Cooke and Wheatstone took out their first patent.

The subsequent history of the electric telegraph need not be dealt with here, except so far as it derives additional interest from the perusal of a somewhat curious work published about fifteen years prior to the inventions of Messrs. Cooke and Wheatstone, which probably attracted little notice at the time, and has long since been forgotten. In 1823—just fifty years ago—Francis Ronalds, of Hammersmith, whose labours in the cause of electric telegraphy were as ardent and persevering as they proved disheartening and unprofitable, published for private circulation a little work entitled "Descriptions of an Electric Telegraph," which it is interesting and instructive to read in the light of what has been achieved in regard to telegraphic communication during the past half-century. Mr. Ronalds appears to have been the first to make the experiment, on any great scale, of sending a current of electricity through an aërial wire, which he erected on a "lawn or grass plot" near his residence at Hammersmith. Of course it was impossible to erect any great length of single continuous wire in such a situation; but Mr. Ronalds very ingeniously surmounted this difficulty by erecting two wooden frames, placed at a distance of twenty yards from each other, each frame being traversed by nineteen horizontal bars, and each bar having thirty-seven hooks, from which depended silken cords, supporting and also insulating a small iron wire. This wire, which made its inflections at the points of support, composed in one continuous length a distance of rather more than eight miles; and when it was charged from a Leyden jar, and the shock passed through two insulated inflammable air pistols, the result was, in Mr. Ronalds's own expressive way of describing it, that "three of the senses—viz., sight, feeling, and hearing—seemed to receive absolute conviction of the instantaneous transmission of electric signs." We need not follow Mr. Ronalds through his detailed account of the experiment; but the impression which it seems to have made on his mind, although recorded in somewhat crude and homely language, is remarkable as foreshadowing very closely indeed what has come to pass since then. He says:—"The result seemed to be that that most extraordinary fluid, or agency, electricity, may actually be employed for a more practically useful purpose than the gratification of the philosopher's inquisitive research, the schoolboy's idle amusement, or the physician's tool; that it may be compelled to travel as many hundred miles beneath our feet as the subterranean ghost which nightly haunts our metropolis, our provincial towns, and even our high roads; and that in such an enlightened country and obscure climate as this its travels would be productive of, at the least, as much public and private benefit." "Why," he asks, "has no serious trial yet been made of the qualifications of so diligent a courier? And if he should be proved competent to the task, why should not our kings hold councils at Brighton with their ministers in London? Why should not our Government govern at Portsmouth almost as promptly as in Downing Street? Why should our defaulters escape by default of our foggy climate? and, since our piteous *innamorati* are not all Alphei, why should they add to the torments of absence those dilatory tormentors, pens, ink, paper, and posts? Let us have electrical *conversazione* offices, communicating with each other all over the kingdom, if we can." It would hardly be possible at the present day to describe more accurately the progress of electric telegraphy than in these characteristic sentences of Mr. Ronalds. We have "electrical *conversazione* offices" all over the kingdom. The wires which practically connect Balmoral, Windsor, and Osborne with Downing Street, enable Her Majesty to "hold councils with her Ministers in London" at any momoment; and the extensive system of Admiralty and War Office telegraphs enables the Government to "govern at Portsmouth (and many places besides) "as promptly as in Downing Street." One of the very first acts of the very earliest telegraph was the capture of Tawell, the Quaker murderer; and the curious ramification of police telegraphy in London, if not an absolute protection against our "foggy climate," is at least a terror to those who might otherwise elude the grasp of the law. As for our "piteous *innamorati*," it is perfectly well known that they use the wires as freely as most people, and that "love telegrams" are gradually taking the place of "love letters."

But, besides foreshadowing many of the uses of the telegraph, Mr. Ronalds has placed on record in his homely treatise many practical suggestions as to its construction and maintenance which are actually being followed—unconsciously, perhaps, for his is no text-book of the science—at the present day. His back garden at Hammersmith appears to have been the scene not only of one of the earliest aerial telegraphs, but also of the first experiment with an underground line. He tells us that "a trench was dug in the garden 525 feet in length, and four feet deep. In this was laid a trough of wood, two inches square, well lined inside and out with pitch; and within this trough thick glass tubes were placed, through which the wire ran. The trough was then covered with pieces of wood, screwed upon it while the pitch was hot; they also, in turn, were well covered with pitch, and the earth then thrown into the trench again." Mr. Ronalds goes on to describe his method of signalling through this experimentally perfect line; and also gives the outlines of a "telegraphic dictionary," by means of which a word, or even a whole sentence, could be conveyed by only three discharges of the wire in a mean space of 54 seconds. Even at such an early stage of telegraphic development, Mr. Ronalds was by no means insensible to the *sine qua non* of a perfect telegraphic system; for he gives it as his opinion that a signal might be transmitted through a buried wire from Carlton House to the Pavilion at Brighton in one minute; and he adds—"Were the time occupied five minutes, I should count this objection rather serious, but "not insurmountable." As a matter of fact telegraphic signals can be transmitted over a continuous wire in an almost imperceptible space of time, the time occupied in transmitting a message being regulated by the number of signals to be transmitted. But Mr. Ronalds's idea of speedy communication was rather in advance of the requirements of his age, and of the means placed at his disposal. His underground telegraph was, however, a very fair specimen of what exists in the present day. We use iron or earthenware pipes in lieu of his wooden trough; but we are not very far in advance here, for he points out in his book, by way of anticipating possible objections to his plan, that cast-iron troughs might be rendered as "tight as gas-pipes," should it be found desirable to employ them. The "thick glass tubes" through which he led his conducting wire have been replaced by that useful substance gutta-percha, which had not been discovered in Mr. Ronalds's day, but which is now used most extensively as an insulating substance in all operations

connected with telegraphy. Not only in the method of constructing, but of testing and keeping in repair our underground telegraphs, have we very closely followed out Mr. Ronalds's ideas. Dealing with the subject generally, he says—"The liability of the subterranean part of the apparatus to be injured by an enemy, or by mischievously disposed persons, has been vehemently objected. If an enemy had occupation of all the roads which covered the wires, he could undoubtedly disconnect my electric signs without difficulty; but would those now in use (the old semaphore, presumably) escape? And this case relates only to invasions and civil wars; therefore, let us have 'smokers' enough to prevent invasions, and kings that love their subjects enough to prevent civil wars. To protect the apparatus from mischievously disposed persons, let the tubes be buried 6 feet below the surface of the middle of high roads, and let each tube take a different route to arrive at the same place." Of course, the danger which Mr. Ronald here suggests has never menaced our lines of underground telegraph. But his notion of alternative routes is precisely what is done in the Postal system as regards overhead wires; the object being, of course, to divide the risk of having the whole communications with certain places devastated by storms like those which have recently played such havoc with the wires. "Could any number of rogues, then," continues Mr. Ronalds in his characteristic style, "open trenches 6 feet deep, in two or more different public high roads or streets, and get through two or more strong cast-iron troughs, in a less space of time than 40 minutes? For we shall presently see that they would be detected before the expiration of that time. If they could, render their difficulties greater by cutting the trench deeper; and should they still succeed in breaking the communication by these means, hang them if you can catch them, d—n them if you cannot, and mend it immediately in both cases." Mr. Ronalds must have rejoiced at having lived to see a time when cutting the telegraph wires, or otherwise wilfully interrupting the communication, was punishable as a felony; but he proposed to rely on other means than Lynch Law in maintaining his system, and here, again, the telegraph engineers of the present day have followed out his ideas almost to the letter. He proposed to keep his wire constantly charged with electricity,—in other words, to work it on the "permanent current principle;" then to have certain "proving stations," as he calls them, at frequent intervals along the line; and a staff of persons who would constantly watch the "provers," and set out the moment that any indication was given that the line was interrupted. Suitable situations for such proving stations he conceived to be "post-offices in towns and villages, turnpike-gates, and the like." Then he continues:—"We will imagine twenty proving stations established between London and Brighton, or any distance of 50 miles, only four persons employed (but not exclusively) to keep watch over them, and each watchman to have the charge of five provers. It is evident that (were he to dwell at the centre one of the five) in order to examine the two on each side of it, he would have to ride only 4$\frac{1}{10}$ miles, which journey he could easily perform in something less than forty minutes, and he would discover that the defect rested somewhere between two of the provers, a distance of 2$\frac{4}{10}$ miles. Any sorry little twopenny post cove might take a canter on his Rozinantuolo, and, on his arrival at a prover, perform the operation on it in less time than I have employed to describe the manner of its performance." Now, what are these innumerable "flush-boxes" which are to be found everywhere in the streets of London, and other large cities, but "provers" of our underground telegraphic system? Most people are familiar with the snake-like coils of apparently dirty rope, but really telegraph wires, which are every now and then laid bare in those curious apertures in the pavement, and the little clock-face, with only a single handle, which is the invariable companion of the workman engaged in the hole. He is simply "proving" a wire which has been found faulty, or, it may be, trying to detect one which has shown too great a liking for its next-door neighbour. Then, again, as regards over-head wires, what are the "linemen" stationed at certain intervals along the route of a trunk line but the "provers" of the section which it is their duty to traverse from time to time, working on either side of their station, precisely as Mr. Ronalds would have worked his "sorry little twopenny post cove?" But besides this, there are certain post-offices along the line which are called "testing stations;" and here every morning the wires are disconnected, with the view of testing their goodness, or the reverse. When a "fault" occurs, it is thus easy to "localise" it between two stations; and hence the rapidity with which communication is now restored after a breakdown, as compared with the time long after Mr. Ronalds's treatise was composed.

Mr. Ronalds was, perhaps, as little vain of his achievements in the telegraphic field as the most modest inventor could have been; but many of his prophecies have been fulfilled to the letter. He suffered much at the hands of those who should have been his best friends, as also did other inventors in the same field,—notably, Mr. Alexander, a Scottish electrician, who could not hear the name of "telegraph" without a shudder. Speaking of his treatment by the Government of that day, Mr. Ronalds says:—"Lord Melville was obliging enough, in reply to my application to him, to request Mr. Hay to see me on the subject of my discovery; but before the nature of it had been yet known, except to the late Lord Henniker, Dr. Rees, Mr. Brande, and a few friends, I received an intimation from Mr. Barrow to the effect that telegraphs of any kind were then wholly unnecessary, and that no other than the one then in use (the old semaphore) would be adopted. I felt very little disappointment, and not a shadow of resentment, on the occasion, because every one knows that telegraphs have long been great bores at the Admiralty. Should they again become necessary, however, perhaps electricity and electricians may be indulged by his Lordship and Mr. Barrow with an opportunity of proving what they are capable of in this way. I claim no indulgence for mere chimeras and chimera framers, and I hope to escape the fate of being ranked in that unenviable class."

Unquestionably, Mr. Ronalds was no "chimera framer." He early devoted himself to the study of a system of communication which has distanced all competitors, whether for Imperial, commercial, or social purposes; he lived to be Sir Francis Ronalds, and to bequeath a valuable collection of electrical works to those who have succeeded him in his labours; and we have seen by the perusal of his simple, yet clear and forcible treatise, describing "An Electric Telegraph," how much and yet how little we have learnt during "Fifty Years' Progress."—*Times*.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

The first meeting of the Session took place on the 13th inst., at the Institution of Civil Engineers, when the new President, Mr. Latimer Clark, read an exceedingly interesting Address "On the Early History and Growth of Telegraphy," which will be fully reported in our next number.

NOTICE TO SUBSCRIBERS.

Arrangements have been made for the publication, in these columns, of a series of biographical sketches of our English electricians, and of elementary papers on the practical construction of a line of telegraph, including the fitting up of offices, the choice and description of instruments, &c.; also for a series of similar papers on Electric Signalling on Railways. These papers will be written by well-known members of the Society of Telegraph Engineers. The papers on Testing, by Mr. H. R. Kempe, will be continued, and those on Duplex Telegraphy, by Mr. W. H. Preece, will be completed.

As it is our desire to make this Journal as useful as possible to the large body of telegraphists scattered over the country, we shall feel grateful for any suggestions for improvement or for hints on shortcomings. We propose establishing an exchange column, by which apparatus, books, periodicals, and other things, can be exchanged among our Subscribers, on the same plan as that which has proved so successful in other cases.

Notes.

Sir Francis Ronalds, "our eminent Fellow," says the President of the Royal Society, bequeathed £500 to that Society, but by payment of legacy duty it has been reduced to £450. His bequest was made in recognition of the advantages he had derived, when Honorary Director of the Observatory at Kew, from the sums granted to him out of the fund to aid him in the construction of his photographic apparatus for the registration of terrestrial magnetism, atmospheric electricity, and other meteorological phenomena. An exceedingly interesting account of his telegraphic projects appeared in *The Times*, which we reprint. It is worthy of record that he anticipated the observations of Siemens and Latimer Clark, and the explanation of Faraday of the Leyden jar action of underground wires. His magnificent library will, it is hoped, become the property of the Society of Telegraph Engineers.

The Institution of Civil Engineers (says that admirable periodical *Nature*) seems to be one of the most prosperous of our Scientific Societies. On its books on November 30th, 1874, were 2130 members; its income for the past year was upwards of £10,000, and its investments amount to nearly £33,000.

Snapper Sounders are now sold in the streets of New York by the street pedlars.

The following statistics—given by Mr. F. L. Pope, in *The Telegrapher*—will interest many of our readers:—

The rate of speed at which wires are actually worked is a matter of endless dispute when discussing this subject (automatic working). I give below the result of six consecutive days' actual work, taken from the records of the New York Western Union Office in 1868:—

Morse Circuits (Sounder).

Wires.	No. of Messages.	No. of Words.
No. 1, to Chicago	2,088	64,728
„ 3, „ Buffalo	1,267	39,654
„ 7, „ Boston	508	55,948
„ 4, „ Baltimore ...	839	40,534
„ 11, „ Washington ...	1,051	33,682
Total for 6 days ...	5,753	234,546

Type Printing Circuits.

No. 5, to Albany	1,308	41,108
„ 1, „ Boston	1,948	79,638
„ 10, „ Do.	1,719	61,979
„ 1, „ Washington ...	1,866	76,342
„ 7, „ Philadelphia ...	1,639	52,509
„ 8, „ Do.	1,754	55,174
Total for 6 days ...	10,234	266,750

If we suppose each wire worked to its full capacity from 9 A.M. to 5 P.M., it would give a total of 240 hours per week for the Morse circuits, and 288 for the printing circuits, and the average result would be as follows:—

Morse, average per hour ... 977 words.
Printing, „ „ ... 1273 „

The circuits included in the above statement were at that time the busiest ones in the New York office.

During the year 1872 several instances of first class work on regularly numbered messages were timed, of which I take a few of the best:—

Morse Circuits.

330 messages in 6 hours 30 mins., 50·7 per hour.
136 „ „ 2 hours, 68 per hour.

Printing Circuits.

606 messages in 7 hours, 86·5 per hour.
700 „ „ 8 hours 45 mins., 80 per hour.

Some of the best work in this country has been done in transmitting the President's annual message from Washington to New York. The time recorded is as follows:—

Year.	No. Words.	No. Wires.	Time.	Average per Hour.
1872	11,339	12	45 mins.	1260
1873	10,635	8	59 „	1368

If we therefore put the best Morse transmission at 1368 words per hour, and divide it by the greatest number of messages per hour given above, which is 68, it gives us an average of 20·1 words per message, which is probably very near the truth. This would give us as the present attainable speed, in actual work, on a circuit of 20 miles, say—

Morse ... ... 1368 words per hour.
Printing ... ... 1738 „ „

Quadruplex telegraphy has been successfully introduced in America by Messrs. Prescott and Edison, and a large supply of apparatus is being manufactured by the Western Union Telegraph Company.

THE TELEGRAPHS OF THE PRINCIPAL COUNTRIES OF THE WORLD.

Countries.	Length of Lines. Miles.	Length of Wires. Miles.	No. Offices.
Argentine Republic...	4,146	8,059	60
Australia	11,878	18,466	326
Austria	11,995	31,510	1,657
Bavaria	4,256	13,875	755
Belgium	2,926	12,561	547
Brazil	2,067	2,211	64
British India	15,568	31,040	770
British Indo-European	3,378	3,114	10
Canada	11,399	18,989	1,143
Chili	2,090	3,143	52
Dutch East Indies ...	2,843	3,458	51
Denmark	1,577	4,364	177
France	30,779	79,963	2,244
German Empire ...	18,999	64,753	3,325
Great Britain	23,878	99,918	5,474
Holland	2,032	7,278	315
Hungary	8,319	28,290	837
Italy	12,087	41,543	1,318
Mexico	2,955	3,338	50
Norway	4,012	6,247	148
Portugal	1,929	3,550	120
Roumania...	2,239	3,629	70
Russia	34,914	68,858	1,333
Spain...	7,287	16,572	215
Sweden	4,371	11,196	320
Switzerland	3,623	8,784	800
Turkey	16,362	28,273	393
United States	85,585	195,135	7,350
Wurtemburg	1,378	3,000	224
	335,872	821,417	30,148

—*Journal Telegraphique.*

Notices of Books.

A Treatise on Magnetism, General and Terrestrial. By H. LLOYD, D.D., D.C.L., Provost of Trinity College, Dublin, &c. London: Longmans, Green, and Co. 1874.

DR. LLOYD'S famous treatise on the wave theory of light marked an epoch in our knowledge of that subject; and now, in his mature age, he has published a work which—though not likely to rank with his former treatise—will unquestionably be of great value to every physicist. The splendid instrumental means for observing the elements of terrestrial magnetism, which Dr. Lloyd devised, and which have been under his superintendence at Trinity College since 1838, have furnished him with magnetic observations probably unequalled for extent and accuracy. Many of the results he has thus obtained have been reported from time to time at the meetings of the British Association, and in this work they are given in an accessible form. Moreover, the theoretical principles involved in the instruments employed in magnetical observatories, as well as the construction and adjustment of the instruments themselves, are fully and admirably detailed in this treatise, which is likely, therefore, to become a standard work for reference on these subjects.

The fact that the present volume—as the author tells us in his preface—was projected, and partly completed, many years ago, probably accounts for the omission of the many valuable contributions to the science of magnetism which have been made of late years by English and Continental physicists. We certainly expected to find some reference to Prof. Clerk Maxwell's famous treatise on "Electricity and Magnetism," but, so far as we remember, it is we believe unnoticed; nor have we met with any recognition of Sir W. Thomson's, nor Prof. Maxwell's, nor Prof. Wertheim's researches. On the other hand, the important laws deduced by earlier philosophers are classified at some length. A full account is given of Coulomb's investigations, and the conclusions he obtained are discussed with care: this portion of the volume will be extremely useful to students. The less frequently quoted experiments of Barlow are here noted, from which the effect of heat was shown to produce two effects on the magnetism of a steel magnet. When a magnet is exposed to a temperature not exceeding boiling water it loses a portion of its magnetism, and, as is well known, it recovers a *part* of this on cooling. So that a moderate heat acts in two directions on a magnet,—destroying one portion of the free magnetism, and rendering latent another portion. Upon this Dr. Lloyd makes the following suggestive remark:—"This two-fold operation of heat, although fully recognised as a fact, has not been sufficiently considered in reference to the cause. There seems reason to believe that the two effects, so dissimilar in their conditions, are in fact referrible to distinct causes; and that while the permanent loss of magnetism is a *dynamical effect* due to the molecular movement in which heat is known to consist, the recoverable portion is probably to be ascribed to the *dilatation* of the body, and to the diminution of the reciprocal action of the magnetic elements consequent upon their increased distance."

Further on we meet with the following striking passage upon the theoretical bearing of the results of heating dia-magnetic bodies, and of the general phenomena of magne-crystallic action. The facts of magnetic induction compel us to admit that the separation of the magnetic fluids is limited to the molecules of a body; hence "we must suppose that the intervals of these molecules are either absolutely void or filled with some substance of a different nature which is impervious to the magnetic fluids. The magnitude of these intervals is of the same order as that of the molecules themselves; but the proportion of these magnitudes is probably different in different bodies. The ratio of the sum of the volumes of the magnetic molecules to the entire volume may be termed the magnetic density of the body. Its magnitude will vary, even in the same body, with temperature, and other physical conditions; and it is upon that that the capacity of the body for magnetism appears to depend. This view is confirmed in a remarkable manner by the other properties of the magnetic metals. Iron and nickel are, as we know, the most powerfully magnetic of all known substances. But when we compare the specific gravities of the metals with their atomic weights, we find that these very metals are those in which the space occupied by the molecules bears the greatest ratio to the entire volume,—*i.e.*, in which the magnetic density is greatest. We are therefore justified in concluding that the capacity for magnetism in these, and therefore probably in other metals, is due to the proximity of the molecules."

Terrestrial magnetism and the description of the instruments in the Dublin Observatory occupy—as we have already remarked—a large and important portion of this treatise. Our limited space forbids us to dwell

on this part of the work. In the Appendix are printed some most useful memoirs; especially we note that on the effect of humidity of the air, on the position of a magnet suspended by silken fibres, and the reprint of Dr. Lloyd's paper on the direct magnetic action of a distant luminary on the diurnal variations of the magnetic force at the earth's surface. In this paper (published originally in the *Philosophical Magazine* many years ago) it is shown that the phenomena of the diurnal variation are *not* caused by any *direct magnetic* action of the sun and moon. And, as Mr. G. J. Stoney has subsequently proved, the *magnitude*—as well as the nature—of the diurnal variation is equally inconsistent with any explanation of the direct action of these bodies.

We feel ourselves but as young and raw students of science when in the presence of Dr. Lloyd's wide experience and powerful grasp of his subject; hence, rather than attempt any criticism of this work, we prefer to listen to the instruction Dr. Lloyd gives us: our readers, we feel sure, will also be glad to have had their attention directed to this able work: for, notwithstanding Dr. Lloyd's advanced age, this treatise is a pleasing evidence that still his eye is not dim to observe, nor does his natural force seem much abated.

[*Written by a Telegraph Clerk on the back of a Message Form.*]

LOST OPPORTUNITIES.

In times that are over, full many a lover
Was won by the power of electrical fire;
There was working, then sporting—conversing, then courting,
And letters by post followed wooing by wire.

The couples then mated are closer related,
And many a one who was helped in his work,
By patience, attention, and care beyond mention,
Has found a kind helpmeet in his fellow clerk.

But, now, things are changing, stern rules are estranging
The workers, and striving all likings to baulk;
Lest people should choose them, and Government lose them,
"*The Staff, on the wires, are forbidden to talk!*"

Odd moments of leisure, once given to pleasure,
Are spent in dull idleness now thro' the day;
And kept thus asunder, can anyone wonder
If patience, at times quite exhausted, gives way?

It is so annoying, one might be enjoying
The cosiest chat with the nicest of friends;
But there's always the fear now that somebody's near now,
And "taking us down from the slip" at both ends.

Correspondence.

CLOSED CIRCUITS.

To the Editor of the Telegraphic Journal.

SIR,—I have often been struck with the fact that in America and in our Colonies the system of closed circuits is almost exclusively used. Can any of your readers inform me why that system is not used in England, or why the open system is not used in America?—I am, &c.,

TELEGRAPHIST.

[*Note.*—As a rule we object to letters appearing in our columns under pseudonyms, because a license is frequently assumed under a *nom de plume* which would not be used if the communication appeared under the writer's proper signature. In the discussion of such purely technical questions as the above we shall withdraw that objection; but every communication must be accompanied by the writer's name and address—not for publication, but as a guarantee of good faith. —*Ed.* TEL. JOURN.]

ELECTRICAL PROBLEM.

To the Editor of the Telegraphic Journal.

SIR,—I submit the following problem to your readers for solution:—

"Transmit alternately positive and negative currents within a closed circuit from a battery all the poles of which are connected in the ordinary manner, using an ordinary Morse key, to which no extra point or appliances whatever is to be added. No device other than the battery, key, and connecting wires is to be used." I enclose two diagrams, both solving the problem in a different manner.—I am, &c.,

THOS. A. EDISON.

Newark, N. J., November 25, 1874.

Electrical Science in English and Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxix., No. 23. December 7, 1874.

On the Actions produced by the Simultaneous Meeting of Battery, and of Electro-capillary Currents.—By M. Becquerel.—M. Becquerel enquiring if it were possible to increase or diminish the intensity of electro-capillary actions by making use of the current of a battery of several elements, used two apparatus. The first was a cracked tube containing a metallic solution, and immersed into an eprouvette with an alkaline solution; the second was a pervious partition apparatus—a tube closed at bottom by a piece of parchment paper and containing a metallic solution. This latter was plunged into an eprouvette containing an alkaline solution. The electro-capillary action was increased by means of two plates of platinum in connection with a battery; the positive plate being immersed into the metallic solution and the negative plate into the alkaline. The resultant electro-chemical actions were very different according to the nature of the solutions experimented upon. Copper and lead were reduced to the metallic state; silver, bismuth, and iron were hydrated with the alkaline; whilst gold and zinc gave no deposit. Wherefore these differences? They result undoubtedly from two existing currents, the lateral and central. The former tends to conduct metals in the metallic state to the negative surface of the pervious tissue, viz., the parchment paper, and at the same time the alkaline and the oxygen are transported to the positive plate. The elements meet on the negative surface, and the effects produced depend upon the affinities of these different substances; thus, if sulphur has a great affinity for the metal a sulphate will be produced. This takes place, as before stated, with silver, bismuth, and iron; but, if the reductive property of the current gets the better of the affinity of the metal for sulphur, a metallic reduction ensues, such as takes place with copper and lead.

On Magnetism.—J. M. Gaugain.—(Paragraphs 82 to 84). The permanent magnetism of a section m.m. may be considered as formed of two parts, the one which is maintained by the coercive action of the section, and the other which results from the actual reactions of all the other sections of the bar.

Nos. 24 and 25. December 14 and 21, 1874.

These numbers contain nothing of interest to our readers.

Journal Telegraphique. Vol. ii., Nos. 33 and 34.

Continuation of Paul Dupré's paper on *Telegraphic Legislation.*

The Jaite Telegraph.—By W. Gerlt, of Berlin.

Sockets for Metallic Posts.—A letter from J. M. Collette, of the Dutch telegraphs. He says, referring to a former paper by M. J. de la Taille on this subject (recommending the fitting of iron posts into concrete blocks), that the description of the line therein described agrees with one erected in Holland during 1873, excepting that the fixing of the posts into concrete blocks was not effected in precisely the same manner. The difference appears to have consisted in first making the concrete blocks in a mould, and then, at the place of erection, fastening the posts into them with cement.

Nature. Vol. xi., No. 268. December 17, 1874.

M. Becquerel—giving his opinion respecting the proposed founding of an Observatory for Physical Astronomy in the vicinity of Paris—states that he divides the formation of our planet in three calorific epochs:—(1.) When the elements were in a gaseous condition, with all the constituents consequently in a dissociated state. (2.) That in which the temperature being sufficiently lowered, affinities commenced to exercise their action. During all the chemical reactions which occurred there would be produced an enormous disengagement of electricity arising from the energy of these reactions, and, as a consequence, a re-composition of the two electricities would rend with vivid gleams the atmosphere already formed. (3.) The formation of water by further decrease of temperature. The same number of this periodical informs us that "A series of experiments has lately been made by the Prussian Government with reference to the use of electricity for the head-light of locomotives, and that a battery of 48 elements makes everything distinct on the railway track to a distance of over 1300 feet."

Bulletino Telegrafico. Anno x. September, 1874.

In addition to official regulations and personal intelligence, this number contains an article on the administration of the telegraphic system in England, taken from *Fraser's Magazine.* The telephone is an instrument devised by Mr. Elisha Gray, of Chicago, for transmitting sounds by means of an uninterrupted electric current. His experiments have already resulted in the transmission of a most intelligible sound to the distance of 2400 miles. The apparatus consists of three parts,—the transmitting instrument, the conducting wire, and the apparatus for receiving the sound. In one of these experiments Mr. Gray sounded, on a small melodium, certain national hymns, which were repeated note for note on a violin connected with the above-mentioned apparatus, 2400 miles away. The transmitting apparatus consists in a key-board with a quantity of electro-magnets corresponding to the number of the keys, to which are attached vibrating tongues or reeds, according to the tones of the musical scale. Each of these tongues may be put in motion separately, by the pressure of the corresponding key. The various tones are obtained by touching the keys exactly as with an ordinary pianoforte or melodium. To the transmitting instrument is attached a conducting wire, of which the termination is connected to the receiving apparatus. The length of the wire connecting the transmitting and the receiving apparatus may be from one to ten thousand miles, provided the insulation be sufficiently perfect to prevent the dissipation of the electric current.

October, 1874.

The non-official portion of this number is taken up with a continuation of the description of the telegraphic system of England, commenced in the September number.

City and Commercial Notes.

The Eastern Telegraph Company's traffic receipts for the month of December, 1874, were £31,725, against £35,238 in the corresponding period of 1873.

The traffic receipts of the Eastern Extension, Australasia, and China Telegraph Company (Limited) for the month of December, 1874, were £18,172, against £20,400 for the corresponding period of 1873.

The Great Northern Telegraph Company's traffic receipts for the month of December, 1874, were 294,338 francs; 1873, 287,356 francs. Total traffic receipts 1st January to 31st December, 1874, 4,427,890 francs; 1873, 3,352,542 francs.

The traffic receipts of the Direct Spanish Telegraph Company (Limited) for December, 1874, were £1271 15s. 4d., against £1224 10s. in November.

The Directors of the German Union Telegraph Company have decided to pay an interim dividend of 11s. 9d. per £15 bond.

The Western and Brazilian Telegraph Company (Limited) have announced an interim dividend of 5s. per share for the past quarter.

The Eastern Extension, Australasia, and China Telegraph Company (Limited) gave notice that the transfer books would be closed from the 8th to the 14th January, both days inclusive, for the purpose of payment of an interim dividend of 3s. per share.

The Eastern Telegraph Company announced that the register of transfers would be closed from the 7th to the 14th January, both days inclusive, preparatory to the payment of the interim dividend of 2s. 6d. per share already announced.

The offices of the West India and Panama Telegraph Company (Limited) have been removed from Old Broad Street to St. Stephen's Chambers, Telegraph Street, Moorgate Street.

The Black Sea Telegraph Company state that telegraphic communication has now been established between Constantinople and Odessa, and the Odessa offices are connected by wires with the Russian land lines.

TELEGRAPH SHARE LIST.

Amount per Share.	Name of Company.	Amount paid up.	Closing Quotations.
£		£	Jan. 14.
Stock	Anglo-American (Limited)	100	74⅜—75¼
10	Brazilian Submarine..	All	6⅝—7⅛
10	Cuba	All	7—7⅛
10	Direct Spanish	9	6—8
20	Direct United States Cable	All	10½—10⅞
10	Eastern (Limited)	All	7⅞—8
..	Do., New	..	103—105
10	Eastern Extn. Australia and China	All	7⅞—8
10	Globe Telegraph and Trust	All	6½—6⅞
10	Do., 6 per cent Pref...	All	10—10½
10	Great Northern	All	11—11½
25	Indo-European	All	16½—17
10	Mediterranean Extension (Limited)	All	3½—4
10	Do., 8 per cent Pref...	All	10½—11
10	Panama and South Pacific	2½	..—..dis
8	Reuter's..	All	11½—12
Stock	Submarine	100	206—211
1	Do., Scrip	All	2—2¼
10	West India and Panama	All	4—4⅜
10	Do., 10 per cent Pref.	All	10—10½
20	Western and Brazilian (Limited) ..	All	14½—15
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	104—106
10	Hooper's Telegraph Works	All	13¾—14
50	India-Rubber and Gutta Percha ..	All	22—24
Cert.	Submarine Cables Trust	100	105—108
12	Telegraph Construction	All	29—29½
100	Ditto Ditto 7 per cent Bonds	All	100—103

To Correspondents.

A Student desires to know the proper pronunciation of the word "electrolysis." He has heard it pronounced "electroly'sis" and "electrol'ysis" by very able electricians. In reply, we have to say that our best lecturers pronounce it in the latter way.